REPORT

OF THE

SUPERINTENDENT

OF THE

UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1898.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

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UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 1, 1898.

SIR: I have the honor to submit the annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1898.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

The report of the astronomical director is as follows:

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 1, 1898.

SIR: In compliance with paragraph 23 of the regulations for the Government of the United States Naval Observatory, I have the honor to submit the following report concerning the operations of the astronomical department for the fiscal year ending June 30, 1898.

THE 26-INCH EQUATORIAL TELESCOPE.

[Prof. STIMSON J. BROWN, U. S. N., in charge.]

As usual, this instrument has been employed almost exclusively on faint and difficult objects, which could not well be reached by smaller telescopes. The work accomplished during the year was as follows:

D'Arrest's periodic comet, 1897 II= *a* 1897, was sought for on almost every favorable occasion from July 9 to September 3, 1897, but it was generally difficult to see on account of its position in the southwestern sky, which is illuminated by the electric lights of the city, and only nine observations were obtained.

Giacobini's comet, *g* 1898, was observed on June 21, 1898, but as it was visible in the 5-inch finder its further observation was left to the 12-inch equatorial telescope.

The observations of the relative positions of Titan and Iapetus during the years 1894, 1895, and 1896 gave for the mass of Saturn 1: (3491.8 $\pm$ 0.81), and as that falls about halfway between the value found by Prof. Asaph Hall and the group of values found, respectively, by Bessel, H. Struve, and A. Hall, jr., it tends to emphasize the difficulty of avoiding systematic errors in observing satellites. As the latter group of values is supported by the result obtained by Dr. George W. Hill from the perturbations of Jupiter by Saturn, it has been surmised that the observations of the relative positions of Titan and Iapetus may have been vitiated by the superior brightness of the former, and therefore it was decided to attempt a determination of the mass of Saturn from observations of the relative positions of Rhea and Iapetus. That work was begun on May 16, 1898.

Observations of the satellite of Neptune were attempted on almost every possible occasion from October 13, 1897, to March 13, 1898, and 41 complete measurements of position angle and distance were obtained.

In order to determine correct formulæ for the semidiameters of Mercury and Venus it is desirable to have measurements of these planets in all parts of their orbits, and to that end a watch has been kept upon them, and measurements have been made with the filar micrometer whenever the seeing was sufficiently good. During the year the diameter of Venus has been satisfactorily determined on 16 occasions and that of Mercury on 3 occasions, the mean results at distance unity being for the diameter of Venus 17.47″ and for the diameter of Mercury 7.21″.

Observations of difficult double stars have been continued on the same general plans as in previous years, and, as usual, the work has been much impeded by the paucity of nights on which high-magnifying power could be satisfactorily used. At the request of Prof. S. W. Burnham, a large number of close doubles discovered by him were included in our observing list, and observations were begun on them in October, 1897. Most of these stars require a power of at least 900 to divide them satisfactorily, but out of fifty-four nights, during which 130 pairs were observed, there were only ten nights on which a power of 888 could be used, and on only three of these ten did the favorable conditions last so long as two or three hours.

During the period May 3 to June 8, 1898, 11 observations were made with the spectroscope to determine the focal curve of the 26-inch telescope. The investigation is not yet complete, but the minimum focal distance was found to be at, or very near to, the spectral line E, and the coordinates of the curve at the other principal lines were as follows:

	Inches.		Inches.
B	0.197	b	0.012
C	.146	F	.142
D	.032	4340	0.918
E	0.000	G	1.233

The office work has been mainly confined to current reductions, together with the revision and preparation for publication of the Titan and Iapetus observations. In addition to this the observations of the satellites of Mars, made in November and December, 1896, have been reduced, and from them, in combination with the observations made at the Lick Observatory, elements have been derived for the orbits of Deimos and Phobos.

Throughout the year much of Professor Brown's time has been absorbed by the work of inspecting and surveying instruments belonging to the nautical branch of the Observatory, and, on account of the detachment of officers for the war with Spain, since May 1 he has acted as storekeeper, and his days have been almost entirely occupied by the inspection and issue of nautical instruments to the Navy. He has also made an investigation and report upon the present condition of our magnetic observatory, including a comparison of its methods and results with those of similar establishments in other countries.

On November 11, 1897, a little water condensed between the lenses composing the object glass of the 26-inch telescope, and the next day Professor Brown removed the objective from its cell, cleaned it, and restored the lenses to their normal condition. With that exception the 26-inch telescope has remained in excellent order throughout the year and its polar axis has maintained its adjustment with very great constancy. The observations made on November 27, 1897, showed that the coordinates of the latter, relatively to the pole of the heavens, were then $\xi = +1' 16''$, $\eta = +1' 44''$.

On June 30, 1897, verniers and index marks were painted on the pointers of the coarse right ascension and declination setting circles of the 26-inch telescope, these adjuncts having been wanting up to that time. December 7, 1897, auxiliary gears were added to the slow-motion handles at the eye end of the telescope, in order to reduce their speed and thus facilitate bringing stars accurately upon the slit of a spectroscope. May 24, 1898, a drip cock was inserted in the oil box which surrounds the screw for driving the polar axis of the telescope, that being necessary to facilitate getting rid of the water which condenses on the mounting of the telescope in damp weather and runs down into the oil box.

After being altered by Messrs. Warner & Swasey, as explained in my last annual report, the chronograph constructed by Messrs. Alvan Clark & Sons in 1875, and employed with the 26-inch telescope in the old Naval Observatory, was remounted here and made ready for use in October, 1897.

In winter, to prevent the hydraulic rams which work the elevating floor from freezing, it is sometimes necessary to drain all the water from them. In such cases they become filled with air, and when the water is again turned on the air gets trapped in the tops of the rams and has heretofore given much trouble by causing the floor to move in an irregular and jerky manner. This defect was remedied on May 24, 1898, by the insertion of a small relief cock in the top of each ram.

THE 12-INCH EQUATORIAL TELESCOPE.

[Prof. EDGAR FRISBY, U. S. N., in charge.]

This instrument was employed during the year in observing comets minor planets, occultations of stars by the moon, eclipses of Jupiter's satellites, and in determining the positions of a few faint stars for the 26-inch equatorial telescope. The work done was as follows:

Thirty-one observations of asteroids were made, namely: 1 of Hebe (6), 5 of Iris (7), 3 of Parthenope (11), 2 of Themis (24), 6 of Danäe (61), 2 of Cybele (65), 1 of Ophelia (171), 7 of Prokne (194), 1 of Unitas (306), and 3 of Eucrate (247).

Perrine's comet, *b* 1898, was observed twelve times.

Coddington's comet, *c* 1898, was observed three times.

Perrine's comet, *e* 1898, was observed once.

Giacobini's comet, *g* 1898, was observed once.

The positions of nine miscellaneous stars were observed for use in connection with the work of the 26-inch telescope.

Four occultations of stars by the moon and fourteen eclipses of Jupiter's satellites were observed.

The above observations are all completely reduced, and the results of the observations of comets have been printed in the Astronomical Journal.

For several years past the 12-inch telescope has been used for the exhibition of celestial objects to visitors on every Tuesday and Thursday evening, weather permitting, and that practice was continued until October 12, 1897; but since then the admission of the public has been limited to Thursday evenings. As usual, permits for these evenings have been issued both by the Observatory and by the Bureau of Equipment. I do not know the total number granted, but during the period covered by this report 1,394 names were entered in the visitors' book, and there were doubtless a considerable number of visitors who did not register.

The alterations and repairs made on the 12-inch telescope during the year just closed were as follows: As the electric lamps for giving bright webs on a dark ground in the field of the large filar micrometer had never worked well, a new arrangement of them was devised by the astronomical director. The necessary changes for bringing it into use were completed on August 18, 1897, and since that date the illumination of both the right ascension and declination webs has been completely under the control of the observer and entirely satisfactory. On October 28, 1897, a 14-volt incandescent electric lamp of 10-candle-power was installed immediately above the automatic dials which indicate the pointing of the telescope, so as to render them visible independently of the general illumination of the room. The contact springs on the polar axis, for transmitting the electric current which lights the circles and field of the telescope, having proved altogether too delicate, a new and more substantial set were inserted on November 4, 1897, and at the same time the declination clamp of the telescope was repaired by securing the rod from the handle more firmly to the Hooke's joint which connects it with the clamping screw. On March 7, 1898, a tooth in one of the beveled pinions of the right ascension quick-motion train was found broken. The pinion in question was of cast iron, and in order to diminish the risk of such an accident recurring in the future, it was replaced by a steel pinion, which was inserted on May 2.

THE 9.14-INCH TRANSIT CIRCLE.

[Assistant Astronomer Aaron N. Skinner, in charge.]

In the work with this instrument Assistant Astronomer Skinner has been aided, for the periods specified, by the following-named gentlemen: Assistant Astronomer Theo I. King, and Computers F. B. Littell, E. A. Boeger, and G. K. Lawton throughout the year, except that on several occasions Mr. Boeger was temporarily detached for periods of a week or more to aid in inspecting nautical instruments; Computer Minott E. Porter from October 11, 1897. Computer William M. Brown has aided throughout the year in observing, but not in computing.

As the observations for the German Astronomical Society's zone, lying between 13° 50′ and 18° 10′ of south declination, were substantially completed in 1896, while the reductions are still far from finished, it was thought best to limit the work of the transit circle during the present year to observations of the Sun, Moon, and planets, together with such stars as were wanted for special purposes, and the minimum number of ephemeris stars necessary for determining instrumental constants.

The observations actually made during the twelve months ending June 30, 1898, are as follows:

Stars required for completing the zone −13° 50′ to −18° 10′, 2; zero stars for zones, 11; American Ephemeris stars, 2,902; miscellaneous stars, 17; Sun, 186; Moon, 184; Mercury, 106; Venus, 148; Jupiter, 40; Saturn, 44; Uranus, 41; Neptune, 50; Hebe (6), 15; Parthenope (11), 13; Amphitrite (29), 7; Danäe (61), 5; Eucrate (247), 7; total, 3,778.

In compliance with special requests the positions of 16 stars, from the zone −13° 50′ to −18° 10′, have been reduced and furnished to Dr. J. Bauschinger, of Berlin, Germany, and the results of certain observations of the major planets have been furnished to the office of the American Ephemeris and Nautical Almanac, as follows: Mars, 14 observations made in 1894; Jupiter, 2 observations in 1894 and 2 observations in 1895; Uranus, 8 observations in 1895, 2 observations in 1896,

and 56 observations in 1897; Neptune, 2 observations in 1894, 2 observations in 1895, 28 observations in 1896, 55 observations in 1897, and 16 observations in 1898.

The reductions of the observations of the sun, moon, and planets are based upon the star places given in the American Ephemeris, and are intended to be wholly differential. During the current year these reductions have been completed throughout the period extending from October 10, 1894, to February 23, 1898, and are very nearly completed through April 7, 1898, but after the latter date they have not been begun. The chronograph sheets have been read off through May 16, 1898.

Owing to the necessity of employing the entire computing force on the reduction of the sun, moon, and planet observations, very little work has been done on the zone observations during the current year. That accomplished was as follows: In right ascension the reduction from the date of observation to 1900 has been interpolated from the tables through zone 64 and checked through zone 55. In declination the reduction from date to the beginning of the year of observation has been interpolated from the tables through zone 59 and checked through zone 28. The total number of zones is 184, and the work necessary for their completion would probably occupy three computers about a year. It is as follows: The preparation of the reduction tables for zones 165 to 184, inclusive; the interpolation in declination from the beginning of the year of observation to 1900 for zones 1 to 59, and from the date of observation to 1900 in zones 60 to 184; the assembling of the observations in order of right ascensions and the taking of the means; the computation of the annual precessions and secular variations, both in right ascension and in declination.

On January 6, 1898, a new open-air thermometer, Henry J. Green, No. 3881, was brought into use for determining the refractions to be employed in reducing observations made with the 9.14-inch transit circle. Its scale is divided to single degrees, from $-12°$ F. to $+126°$ F., and the mean length of 1 degree is 0.080 inch.

The cases of the transit circle counting clock by Parkinson & Frodsham, Change alley, and of the prime vertical clock, by Charles Frodsham, 84 Strand, London, having become much injured on account of deterioration of the glue from fifty years' exposure in the observing rooms, they were thoroughly repaired by Mr. A. E. Wurdeman in July, 1897.

The mounting of the clocks upon the new piers described in my last annual report was much delayed by the ill health of Mr. Gardner, the Observatory instrument maker. There are five piers in the clock room, and upon four of them clocks were mounted and brought into use on the following dates, namely: On July 21.8, 1897, the sidereal clock, E. Howard & Co., Boston, Mass., No. 404, which is the working standard used with the 9.14-inch transit circle; on July 28, 1897, the mean time clock, Parkinson & Frodsham, Change alley, London, No. 611, which had previously been running on sidereal time, its pendulum having been screwed up for that purpose; on August 4, 1897, the standard sidereal clock, Kessels, Altona, No. 1324, and on November 8, 1897, the sidereal clock, Charles Frodsham, 84 Strand, London.

The clock room is provided with steam-heating apparatus, and its temperature is never allowed to vary rapidly; but, as an additional precaution, on January 24–25, 1898, each of the four clocks just mentioned was inclosed in a small wooden house, measuring 3 feet 6 inches by 4 feet on the floor, and 7 feet 1 inch high, provided with a

door having a glass window, through which the face of the clock can be seen without opening the door itself.

Ever since the occupation of the present clock room, much difficulty has been experienced in keeping the clocks mounted therein free from rust during the winter months. The source of this evil was finally found in the steam-heating apparatus, whose relief valves were so arranged that they frequently permitted steam to escape into the room, and thus kept the atmosphere saturated with moisture. Last January this was remedied by equipping these valves with pipes, which now deliver the waste steam outside the building.

The mounting of the 9.14-inch transit circle counting clock, by Parkinson & Frodsham, Change alley, upon the new marble pier on the east side of the east transit circle room, was completed on November 16, 1897, and the clock was immediately brought into use.

THE NEW 6-INCH STEEL TRANSIT CIRCLE.

This instrument was built by Messrs. Warner & Swasey, of Cleveland, Ohio, in pursuance of their contract dated March 20, 1893, under the immediate supervision of the present Astronomical Director, and in accordance with minutely detailed specifications and instructions furnished by him. In order to reduce the effects of flexure and changes of temperature to a minimum, it is constructed entirely of steel, the two halves of the telescope tube having each been turned out of a solid steel bar 11 inches in diameter and 28 inches long and the interior both of the telescope tube, the cube, and the axis having been machined out so as to give every part precisely the thickness it was intended to have.

The telescope has a clear aperture of 6 inches, with a focal distance of 72 inches, and is provided with bright and dark field illumination, a system of right ascension and declination wires similar to those in the 9.14-inch transit circle, a right ascension micrometer, a zenith distance micrometer, and four eyepieces magnifying, respectively, 72, 102, 144, and 204 diameters, together with all necessary sunshades and nadir caps. The axis is 36 inches long, the pivots are of hardened steel, 2.24 inches in diameter, and the clamp is provided with double joints so as to preclude the possibility of its transmitting any pressure to the pivots. There are two steel circles, each 26.75 inches in diameter, divided upon silver to every two minutes, and each read by four micrometer microscopes. The graduation is figured at every degree, with numbers small enough to be read both in the setting and in the micrometer microscopes, and for determining the errors of graduation two auxiliary microscopes are provided. The illumination of the circles and of the field of the telescope is derived from a common source, which can be instantly changed from gas to electric light by the mere pushing of a slide. The adjustments for level and azimuth are of the most solid description, and so arranged that they can always be brought into a condition which is equivalent to their complete elimination. A hanging level, several pieces of special testing apparatus, a reversing carriage, and a movable mercury basin for reflection observations of stars are also provided.

One vertical and two horizontal collimators are mounted in connection with this instrument, each having a clear aperture of 4.05 inches, The vertical collimator has a focal length of 51.5 inches, and is provided with a collimating cap, while the two horizontal collimators have a focal length of 48 inches, and are provided with a striding level, and stops so arranged that the collimators can be rotated accurately through

arcs of 90° in order to eliminate collimation both in a vertical and in a horizontal direction.

The 6-inch transit circle is mounted in the west transit circle house, whose interior was left unfinished when the building was erected. The marble piers for the transit circle and collimators were put in place in June, 1896. The wooden floor beams were placed on the iron girders; the iron tracks for the reversing carriage and mercury basin, together with the turntable, were put in, and the lower floor was laid in November, 1897. The transit circle and collimators were set up in December, 1897, the upper floor was laid in March, 1898, and the curtains for protecting the instrument during observations of the sun were put up in May, 1898. A number of fittings have yet to be provided before the instrument will be ready for use, but they are being pushed forward as rapidly as possible.

THE NEW 5-INCH STEEL ALTAZIMUTH INSTRUMENT.

[Assistant Astronomer GEORGE A. HILL, in charge.]

This instrument was built by Messrs. Warner & Swasey, of Cleveland, Ohio, in pursuance of a requisition dated November 7, 1894, under the immediate supervision of the present Astronomical Director, and in accordance with minutely detailed instructions furnished by him. It is intended to be used either as an altazimuth instrument, as a vertical circle, or as a zenith telescope; is constructed of steel upon the same principles as the 6-inch transit circle, and the details of its circles, microscopes, and clamps are, so far as possible, identical with those of that instrument. The telescope has a clear aperture of 5.02 inches, with a focal length of 50 inches, and is provided with two latitude levels for use in accordance with Talcott's method. It has bright field illumination, 9 right-ascension wires, a zenith-distance micrometer, 8 positive eyepieces—namely, 4 Frauenhofer's and 4 Kellner's, magnifying, respectively, 49, 70, 100, and 148 diameters—and 1 long diagonal eyepiece magnifying 70 diameters. The horizontal axis of the telescope is 25.0 inches long, with pivots 1.87 inches in diameter. The instrument has 1 horizontal and 1 vertical circle, both of steel, 24 inches in diameter, and both divided upon silver to every two minutes. The horizontal circle is read by 3 micrometer microscopes, the vertical circle is read by 4 micrometer microscopes carried upon an alidade provided with 2 levels for determining the position of the zenith point, and there are 2 auxiliary microscopes which can be used for investigating the graduation errors of either circle. The field of view of the telescope, the alidade levels, and all the circle microscopes are illuminated by a single lamp, which is carried by the instrument and reverses with it.

The altazimuth instrument is mounted, approximately, 273 feet = 2.70″ north and 157 feet = 0.132^s west of the center of the clock room, in a circular wooden building, 11 feet 10 inches in diameter, covered by a revolving dome having a slit 28 inches wide extending through an arc of 135°. The pier which carries the instrument is of brick, 48 inches square at the bottom, and resting upon a mass of concrete 6 feet in diameter, whose base is 4 feet below the surface of the ground. The brick part of the pier is 48.5 inches high, capped by a block of marble 36 inches in diameter and 12 inches thick, upon which the instrument stands.

The site of the altazimuth instrument was agreed upon after an exhaustive discussion by the whole astronomical staff of the Observa-

tory, and was marked on the ground on August 10, 1897, by the superintendent, the astronomical director, and Assistant Astronomer Hill. The pier and the foundation for the building were constructed in August and September, 1897; the building was erected in the end of November, and the instrument was mounted in December, but on account of some small changes which proved necessary it was not brought into use until February, 1898. The first observations with it, used as a zenith telescope and as a vertical circle, were made, respectively, on February 8 and February 24, and by June 30, 1898, 293 zenith telescope observations and 71 vertical circle observations were accumulated, a further account of which is given in connection with the prime vertical transit instrument. It was soon found that in observing stars in the daytime the revolving dome sometimes came into such a position as to expose the instrument to the sun's rays, and to remedy this, and at the same time afford a means of protecting the instrument from the wind when necessary, movable curtains were fitted inside the slit during the latter part of May, 1898.

When the 6-inch transit circle and the 5-inch altazimuth instrument were contracted for, this Observatory was severely criticised, first, for intrusting them to an American firm, and, second, for venturing to make an altazimuth at all. I think we have now had sufficient experience with both instruments to show that the workmanship will compare favorably with anything ever turned out of a European workshop, and that the altazimuth instrument used as a vertical circle will give more accurate declinations than can be obtained with a transit circle.

THE PRIME VERTICAL TRANSIT INSTRUMENT.

[Assistant Astronomer GEORGE A. HILL, in charge.]

This instrument has been used in connection with the small meridian instrument, Stackpole & Bro., No. 1502, up to February 4, 1898, and since then in connection with the new altazimuth instrument, for determining variations of latitude and the constants of aberration and nutation, precisely as described in former reports.

The number of observations obtained during the twelve months ending June, 30, 1898, was as follows: With the prime vertical transit instrument, μ Andromedæ, 16; α Canum Venaticorum, 7; θ Aurigæ, 31; α Lyræ, 102; 40 Cygni, 4. With the Stackpole meridian instrument used as a zenith telescope, α Lyræ, 66. With the new altazimuth instrument used as a zenith telescope. α Canum Venaticorum, 21; γ Bootis, 24; α Lyræ, 46. Total, 317 observations. This is 12 per cent less than the number of observations obtained during the fiscal year 1896–97, but the difference is accounted for by the unusual prevalence of cloudy weather in the spring of 1898.

In addition to the above observations of close zenith stars, it was intended to make another series upon certain bright stars of somewhat greater zenith distance, employing for that purpose the altazimuth instrument used as a vertical circle, but upon trial it was found that the zenith points given respectively by the upper and lower alidade levels of the altazimuth differed systematically, and the cause of this discordance was not discovered until the end of July, 1898. During the continuance of the uncertainty respecting the indications of the alidade levels the instrument could best be employed as a zenith telescope, and accordingly 202 observations of 39 pairs of stars were made with it between April 2 and June 30, 1898.

All observations with the prime vertical transit instrument are com-

pletely reduced, and those made prior to January 1, 1898, are copied on sheets for the printer. The zenith telescope observations made with the Stackpole meridian instrument are also all reduced, but those made with the altazimuth instrument are only provisionally reduced because of a doubt as to the exact value of a revolution of the micrometer screw. That can be best determined from observations of certain stars in the Pleiades, but soon after the instrument was mounted they passed into the daylight. When they come into a suitable position this fall a careful series of observations will be made upon them.

All our observations for variation of latitude, both with the prime vertical transit instrument and with the zenith telescope, up to October 17, 1897, have been sent to the Centralbureau der Internationalen Erdmessung, and were used by Dr. Th. Albrecht in his "Bericht über den Stand der Erforschung der Breitenvariation im December, 1897."

Prior to 1897.55 there were made here 852 prime vertical observations and 370 zenith telescope observations, all of which have been reduced with the star-places given in the "Catalogue of fundamental stars for the epochs 1875 and 1900, reduced to an absolute system," prepared under the direction of Prof. Simon Newcomb, and from them I find for the latitude of the center of the clock room of the Naval Observatory + 38° 55′ 13.97″.

THE TRANSIT CIRCLE STAR CATALOGUE.

[Prof. JOHN R. EASTMAN, U. S. N., in charge.]

In the preparation of this catalogue Professor Eastman has been assisted throughout the year by Mr. F. H. Parsons, temporarily employed for the purpose, and by Computer William M. Brown, who has devoted about two-thirds of his time to the work. The comparisons of the transit circle star-places with those given by other authorities, including the new "Catalogue of fundamental stars for the epochs 1875 and 1900, reduced to an absolute system," by Professor Newcomb, have been continued during the last twelve months, with the result of weeding out some errors, and the explanatory text and discussions pertaining to the annual results have been completed. The manuscript was put into the hands of the printer about the middle of February, and the composition and stereotyping will certainly be completed before August 1, 1898. The work is entitled "The second Washington catalogue of stars, together with the annual results upon which it is based; the whole derived from observations made at the United States Naval Observatory with the 8.5-inch transit circle during the years 1866 to 1891 and reduced to the epoch 1875.0," and will form a quarto volume of 350 pages. It contains the places of 5,151 stars, based upon 72,914 observations, and to obtain the utmost possible security against typographical errors the last proof reading was made upon impressions taken from the stereotype plates.

MISCELLANEOUS MATTERS.

Mr. Charles T. Fellows, who had been attached to the Observatory as photographer since August 11, 1893, died on April 8, 1898, after being in bad health for some months. He knew his business thoroughly, and discharged his duties so pleasantly and efficiently that I fear it will be difficult to find another man who will be in all respects as satisfactory.

During the year the following named articles have been added to the permanent equipment of the astronomical department: July 30, 1897,

one Weston's standard portable alternating and direct current voltmeter No. 1647, one Weston's direct reading voltmeter No. 6719, and one Weston's direct reading ammeter No. 3383. On the same date there was also received a new cover for the heliostat and objective of the 40-foot photoheliograph; November 30, one polished mahogany box, with lock and key, in which are packed the micrometer and eyepieces belonging to the 9.6-inch equatorial telescope, and two polished mahogany boxes in which are packed various pieces of apparatus belonging to the 9.14-inch transit circle.

Very respectfully,

WM. HARKNESS,
Professor of Mathematics, U. S. N., Astronomical Director.

The SUPERINTENDENT U. S. NAVAL OBSERVATORY,
Georgetown Heights, D. C.

DEPARTMENT OF THE NAUTICAL ALMANAC.

Upon the detachment of Prof. William W. Hendrickson, U. S. N., this department was, upon the recommendation of the Superintendent of the Observatory, placed under the charge of the astronomical director.

It was believed that, in view of the relations of these two departments to each other, better results could be obtained if both were under the same general control. As far as can be inferred from one year's experience, this expectation has been realized.

The report of the Director of the Nautical Almanac is given below:

NAUTICAL ALMANAC OFFICE,
UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 1, 1898.

SIR: I have the honor to submit the following report respecting the operations of the Nautical Almanac Office for the fiscal year ending June 30, 1898:

PRINTING.

The books printed during the year were received from the Government Printer on the following-named dates: The American Ephemeris for 1900, first edition, December 6, 1897; the American Nautical Almanac for 1898, third edition, April 4, 1898, fourth edition, May 4, 1898; the American Nautical Almanac for 1899, second edition, November 2 to 29, 1897; the American Nautical Almanac for 1900, second edition, November 22, 1897; the American Nautical Almanac for 1901, first edition, June 30, 1898; the Pacific Coaster's Nautical Almanac for 1898, first edition, September 24 to October 29, 1897, second edition, March 24, 1898; Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac, volume 8, part 1, The Precessional Constant, July 30 to August 17, 1897.

DISTRIBUTION OF PUBLICATIONS.

During the fiscal year ending June 30, 1898, the sale and distribution of publications were as follows:

Title.	Sold.	Distributed.	Bureau of Equipment.	Public service.	Total.
American Ephemeris	545	309	179	631	1,664
American Nautical Almanac	2,565	.....	40	337	2,942
Pacific Coaster's Almanac	1,503	.....	.....	52	1,555
Astronomical Papers	56	131	.....	.....	187

The proceeds of the above sales amounted to $1,368.48, and, in compliance with law, that money has been deposited to the credit of the Treasurer of the United States, on account of public printing and binding.

NEW TABLES OF THE PLANETS.

Upon the retirement of Prof. Simon Newcomb, U. S. N., in March, 1897, he was appointed to supervise the completion of his tables of Mars, Uranus, and Neptune, and since then he has constantly had the services of two of the best assistants in the office, and whenever he desired additional computers they have been furnished him so far as they could be spared from other duties. The manuscript of the tables of Mars was sent to the printer on January 18, 1898, and the composition and stereotyping were completed in the end of May, but on account of the extra work entailed upon the Government Printing Office by the war with Spain the printing is not yet commenced. The tables of Uranus and Neptune are so far advanced that Professor Newcomb hopes the manuscript will be ready for the printer some time in October.

CATALOGUE OF STANDARD STAR PLACES.

"The Catalogue of Fundamental Stars for the Epochs 1875 and 1900, reduced to an absolute system," which was undertaken by Professor Newcomb under the auspices of the Paris conference of May, 1896, will form a quarto volume of about 290 pages, and will soon be ready for issue. The manuscript was sent to the printer on June 17, 1898, and 170 pages were in type at the end of the fiscal year.

CONSTANTS OF PRECESSION, ABERRATION, AND NUTATION.

The values of the constants of aberration and nutation adopted at the Paris conference of May, 1896, together with an unique value of the constant of precession, were introduced by my predecessor into the American Ephemeris for 1900, and the apparent places of the fixed stars were calculated with these constants, but this procedure met with so much opposition among prominent American astronomers that it has been thought best to give in the Ephemeris for 1901 sufficient data to enable either the constants of Struve and Peters or those of the Paris conference to be used with equal facility, and thus each astronomer is left free to choose for himself which he will employ. The retention of the Struve-Peters constants in the Ephemeris for 1901 has necessitated the computation of a new set of star tables, the old ones having run out in 1900, but, notwithstanding the extra work thus thrown upon the Office, it is believed that the Ephemeris for 1901 will be issued at a relatively earlier date than was that for 1900.

Very respectfully,

WM. HARKNESS,
Professor of Mathematics, U. S. N.,
Director Nautical Almanac.

The SUPERINTENDENT U. S. NAVAL OBSERVATORY,
Georgetown Heights, D. C.

Department of Nautical Instruments.

The following report of Prof. Stimson J. Brown, United States Navy, gives the history of the personnel and a statement of work in this department.

The recommendation that the system by which chronometers and sextants are purchased be extended to other instruments is approved, but it is suggested that no steps be taken in this direction until the extraordinary demands due to the existing war cease, when plans for such extension can be fully and carefully considered.

Sir: I have the honor to submit the following report for the fiscal year ending June 30, 1898, of the department of nautical instruments and of the general storekeeper's department combined, as the work of the two has been generally merged together on account of the lack of sufficient force of officers to carry them on separately.

Lieut. T. M. Brumby, United States Navy, was in charge of the department of nautical instruments from October 1 to October 30, 1898, when he was detached and ordered to sea. I have had general supervision of this department, assisted in the examination of instruments by Computer E. A. Boeger, who has performed nearly all the work of inspection.

The purchase of sextants by award of contract to lowest bidder was so far modified as to invite instrument makers to submit sextants made in accordance with careful specifications, the contract to be awarded at a stated price to the maker whose instruments showed the highest accuracy and perfection of work. Four firms submitted a sample sextant of the two classes called for (a high-grade sextant at $100 and a surveying sextant at $90), with the exception of Warner & Swasey, who submitted only the sample high-grade sextant. As a result of the competition, the contract for the high-grade sextant was awarded to Warner & Swasey, of Cleveland, Ohio, and for the surveying sextant to F. E. Brandis, Sons & Co., of Brooklyn, N. Y.

I think this principle could be extended, to the advantage of the Department, to the purchase of nearly all the nautical instruments for the use of the Navy.

The number of instruments purchased and inspected will be given in a table under the general storekeeper's report.

The duties of general storekeeper were performed by Commander Walton Goodwin, United States Navy, until his detachment for sea duty, May 18, 1898. Since that date these duties have been performed by me in addition to my regular duties with the 26-inch telescope.

The following table shows the number of instruments inspected and purchased, the number purchased abroad, and the number issued to vessels of the Navy and to other sources. This does not include the chronometers, comparing watches, and stop watches, which are given in the report of department of time service and chronometers, as also several miscellaneous instruments and apparatus used in connection with the ships' compasses.

Nautical instruments inspected, purchased, and issued.

Instrument.	Purchased after inspection.	Purchased abroad.	Issued.
High-grade sextants	7	.....	36
Ordinary sextants	7	*a* 44	13
Surveying sextants	32	.....	33
Octants	42	25	100
Binocular glasses	320	.....	424
Spyglasses:			
Quartermaster	202	.....	135
Officer of the deck	125	.....	183
Three-arm protractors	20	.....	10
Thermometers	100	.....	100
Aneroid barometers	101	.....	89
Cases captains' reading glasses	25	.....	15
Navigators' dividers	75	.....	75
Psychrometers	45	.....	26
Deck clocks	100	.....	72
Boat clocks	50	.....	24
Clinometers	20	.....	24
Radiimeters	6	.....	6
Stadimeters (Fisks)	.....	.....	2
Telemeters (Lowry)	10	.....	3
Parallel rulers (Sigsbee)	35	.....	31
Parallel rulers, 15, 18, and 24 inch	125	.....	145
Cases drawing instruments	25	.....	15
Standard steel tapes	25	.....	10
Theodolites	.....	.....	3
Surveyors' levels	.....	.....	1
Sets magnetic instruments	.....	.....	6
T-squares	25	.....	20
Artificial horizons	.....	.....	7

a Of the 44 ordinary sextants purchased abroad by the naval attaché at London, 19 were kept at the New York Navy-Yard for issue.

The aggregate value of the instruments purchased was $45,781.98. There were made 345 shipments of instruments, the invoice value of which was $56,467.40. These amounts are largely in excess of the general experience of the Observatory, and are due to the sudden demands incident to the naval operations against Spain. The extent of the demand may be best shown by a comparison with the shipments for the last three previous years. These were—

	Shipments.	Value (approximate).
1895	92	$17,443
1896	178	29,117
1897	186	24,088
1898	295	41,853

The last were made in the period from March 1, 1898, to May 16, 1898. To meet this increased demand all the available nautical instruments in this country were purchased and additional supplies purchased from abroad. In no case was there any delay in supplying demands, although the Observatory force was largely reduced by the detachment of officers for service at sea.

Respectfully submitted.

S. J. BROWN,
Professor Mathematics, U. S. N.,
Head of Department of Nautical Instruments,
and Acting General Storekeeper.

Department of Chronometers and Time Service.

The heads of this department during the year have been as follows: Lieut. Charles E. Fox, United States Navy, from July 1 to October 20, 1897; Lieut. A. N. Mayer, United States Navy, from October 20, 1897, to June 18, 1898, and Prof. H. M. Paul, United States Navy, from June 18 to the end of the fiscal year.

Professor Paul was on duty in the department during the whole year, and Computer M. E. Porter from July 1 to October 11, 1897. Professor Paul makes the following report:

CHRONOMETERS.

Sir: The opening of the war with Spain interfered with the regular annual trial of repaired chronometers and of those submitted for purchase. The trial in the temperature room was begun on January 10 with 26 repaired chronometers (20 M. T. standards, 2 M. T. B. C., 2 Sid. B. C., and 2 Thermometric) and 13 new ones. These, together with the ones still unissued from the previous year's trial, would ordinarily have sufficed for issue during the year 1898–9; but the demand for chronometers for the "mosquito fleet" and other newly acquired vessels quickly exhausted the supply on hand, encroached upon the trial (some being issued before the temperature trial was completed), and, before the end of the twelve weeks' subsequent trial in the chronometer room, all the 20 repaired standards and the 13 new ones were issued and afloat, the new ones having all been purchased without completing their regular trial.

This is the reason for the omission from this report of the usual tabular pages of rates and resulting trial numbers. For the same reason the above-mentioned chronometers, and the much larger number subsequently purchased which are referred to below, have all been issued to vessels without the usual temperature coefficients and rate curves.

The demands of the rapidly growing auxiliary navy required emergency purchases of chronometers, many of them being issued to vessels after a trial of only two or three weeks at the Observatory. The supply of new chronometers in this country was soon exhausted and 25 were ordered by cable from London. Of these latter, 10 were issued direct from the New York Navy-Yard, the other 15 coming to the Observatory. These 15 proved fairly satisfactory, although nearly all that remained here many weeks showed a considerable acceleration of rate, as most new chronometers do.

Later on, a considerable number of nearly new chronometers were purchased of makers in this country after a trial of a few weeks at the Observatory, and the supply of these in American makers' hands, together with the new ones now in process of manufacture, will probably suffice for all future demands without further purchases abroad.

Eleven chronometers have been purchased with the newly acquired vessels, and 7 of the best of these have been left on board as standards, and the others cleaned, repaired, and issued as hacks.

Four standards have been condemned to be used as hacks, and 3 second-hand ones purchased for similar use, the supply of hacks having run out and being still short.

The whole number of chronometers received and issued during the year is most concisely and conveniently shown in the following tabular statement:

	Receipts.								Issues.			
	By purchase.				Turned in from—							
	New.	Nearly new.	With ships.	For hacks.	Ships.	Shore stations.	Makers, repaired.	Condemned to be hacks.	To ships.	To shore stations.	To makers for repairs.	Condemned to be hacks.
M. T. standards	34	46	7	.....	45	.....	39	.....	131	1	40	4
M. T. hacks	.....	.....	4	3	9	1	16	4	24	.....	17	.....
M. T. bk. circ	.....	.....	.....	.....	.....	1	2	.....	.....	.....	1	.....
Sid. bk. circ	.....	.....	.....	.....	.....	3	2	.....	1	3	4	.....
Sid. standards	.....	.....	.....	.....	.....	.....	1	.....	.....	1	1	.....
Thermometric	.....	.....	.....	.....	.....	.....	2	.....	.....	2	.....	.....

The above table includes the chronometers received and issued at Mare Island, Cal., for the Pacific and Asiatic squadrons, in addition to the same for the Observatory.

The large numbers of 94 chronometers purchased and 156 issued to ships (most of them in the last four months) are striking illustrations of the war demands upon this branch of the service.

The present location of all the chronometers belonging to the Navy is shown in the following table:

Description.	Location.									Total.
	Outside Observatory.			At Observatory.						
	In service afloat.	At Mare Island.	At other shore stations.	Ready for issue.	In use at Observatory.	Undergoing repairs.	Held for repairs.	Held for survey.	Held for museum.	
M. T. standards	238	39	11	19	.....	.....	.....	.....	3	310
M. T. hacks	66	11	21	.....	3	2	.....	17	18	138
M. T. bk circ	.....	1	4	2	.....	.....	.....	.....	.....	7
Sid. bk circ	1	2	1	.....	4	3	.....	.....	.....	11
Sid. standards	.....	1	.....	.....	1	.....	.....	.....	.....	2
Sid. hacks	.....	.....	.....	.....	3	.....	.....	.....	.....	3
Thermometric	.....	.....	.....	.....	2	.....	2	.....	.....	4
Pocket	.....	.....	1	.....	.....	3	2	.....	.....	6
Total	305	54	38	21	13	8	4	17	21	481

The chronometers at Mare Island are for issue to the Pacific and Asiatic squadrons and to the shore stations of the Pacific coast. The 17 chronometers held for survey are nearly all worn-out hacks which should be condemned. Twenty-one chronometers are held for display in an Observatory museum whenever space is available for it. They are all of some historical interest, mostly connected with arctic exploration. Very few of them are serviceable, but they are reserved from condemnation on account of their history.

WATCHES.

During the year 90 comparing watches and 32 stop watches have been purchased, and 87 comparing watches and 34 stop watches issued

to ships. There remain on hand ready for issue 22 comparing watches and 16 stop watches.

THERMOMETERS.

There have been issued to ships during the year 19 maximum and minimum thermometers, and 7 are on hand for issue. None have been purchased during the year.

TIME SERVICE.

The one sidereal and two mean-time standard clocks, as well as the two transmitting clocks for noon signals, have all performed fairly well, and the noon signals have been sent out every day in the year except Sundays. Recently the signals have been sent occasionally on Sundays for the benefit of the warships and transports at Key West. The reports from the branch hydrographic offices show a fair degree of regularity in the dropping of the time balls under their control.

Computer M. E. Porter has rendered very efficient service in all branches of the work in this department.

Very respectfully, H. M. PAUL,
Professor of Mathematics, United States Navy,
Head of Department of Chronometers and Time Service.

DEPARTMENT OF MAGNETISM AND METEOROLOGY.

In the last annual report of the Observatory attention was called to the disturbances of the magnetic instruments caused by the proximity of electric railways. The same conditions exist now and, owing to extension of electric-railway systems, to a greater degree. Unless legislation can be secured preventing the use of circuits which permit the escape of electricity into the ground, it is feared that the usefulness of the magnetic plant of this Observatory will be entirely destroyed.

It is of interest to note that other magnetic observatories have had the same experience. Those at Toronto, Greenwich, Lyons, and Clermont-Ferrand have been rendered practically useless by electric railways constructed in their vicinity, and the observatory at Saint-Maur, France, is threatened with a like misfortune.

LIBRARY.

Assistant Librarian William D. Horigan has direct charge of the library, under the general supervision of the library committee:

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1897	16,036	3,411	19,447
Accessions	564	156	720
Contents July 1, 1898	16,600	3,567	20,167

Of the accessions, 341 were received as exchanges and 379 were purchased.

The report of the Superintendent for 1897 was distributed.

BUILDINGS AND GROUNDS.

All of the buildings connected with the Observatory are in good condition.

A small building adapted to the use of an equatorially mounted instrument has been erected for the recently purchased alt-azimuth instrument.

The west transit-circle house has been completed in the manner described in the report of the Astronomical Director, for the mounting of the new 6-inch transit instrument.

Owing to the reduction in the amount appropriated for the purpose, no very marked progress has been made in new improvements to grounds and roads, but they have been kept in satisfactory order.

Very respectfully,

R. L. PHYTHIAN,
Commodore, U. S. N., Retired,
Superintendent of Naval Observatory.

The CHIEF OF THE BUREAU OF EQUIPMENT,
Navy Department.